Thermal Oil Boiler Boil-Out: Principles and Procedure

Thermal oil boil-out removes residual water and entrained air from the system before normal operation.

1. Physical mechanisms during cold startup

1.1 Mechanical dispersion in cold thermal oil

Thermal oil has a relatively high kinematic viscosity at ambient temperature. During initial circulation, shear from the main circulating pump disperses residual air and free water into small bubbles and droplets. The viscous oil slows their separation, producing an aerated oil mixture and, where water is present, an oil–water emulsion.

When assessing cold circulation, consider the system pressure reference point, the hydraulic model and suction-line losses.

1.2 Low pressure during cold circulation

Entrained air reduces the average density of the mixture. Compression and expansion of bubbles in the impeller also reduce effective pump performance, so the indicated pressure can be lower than the normal operating pressure.

When wide pressure fluctuations settle to a steady, lower reading, gas binding has diminished. Confirm continuous circulation and the required flow before firing. Controlled heating is then needed to reduce viscosity and assist further air and moisture removal.

1.3 Why heating assists air and moisture removal

Heating sharply reduces oil viscosity. Under the conditions described by Stokes' law, lower viscosity increases the rise velocity of small bubbles, helping them separate from the oil. Meanwhile, free water vaporizes and expands sharply. The released air and vapor pass through the oil–gas separator and the system's designated venting arrangement.

Heat input must remain controlled so that vapor formation does not interrupt circulation.

1.4 Low oil level in the expansion tank

In an elevated expansion-tank arrangement, the oil column provides static head at the pump suction. If the level falls to the oil–gas separator or below and the liquid connection is lost, this static-head contribution is lost. Air entering the suction line can cause gas binding, loss of prime and severe pump noise.

Stop heating if oil level is too low, circulation is lost or severe cavitation occurs. Investigate the cause and follow the system's shutdown procedure.

2. Boil-out stages for a 280°C thermal oil system

The temperatures, heating rates and holding times below are experience-based reference points for this type of system. Use the values approved for the actual thermal fluid and equipment.

Ambient to 90°C

Physical condition: Cold-circulation deaeration: dispersed air gradually escapes through the expansion tank, reducing gas binding in the circuit.

Procedure: Start with the system filled with oil. Run the circulating pump with the heater off. Confirm continuous circulation before firing and beginning the initial temperature rise.

Checks and observations: Pressure fluctuations diminish and the gauge settles at a reading below normal hot operating pressure. Required circulation is confirmed.

Around 95°C

Physical condition: Initial vapor release: oil near a heated surface may be hotter than the bulk reading, allowing local water boiling. Low-boiling constituents may also be released.

Procedure: First holding stage: reduce or stop firing and account for the temperature rise caused by residual furnace heat. Avoid overshoot that could cause gas binding and loss of flow.

Checks and observations: Slight pressure movement and initial vapor release may occur. Resume gradual heating as vapor release subsides and circulation remains stable.

105–130°C

Physical condition: Main moisture-removal stage: residual water vaporizes. Vapor entering the pump can cause cavitation; excessive vapor formation can cause surging or expansion-tank overflow.

Procedure: Keep heat input low and limit the temperature rise while circulation is stable. Stop heating and investigate severe cavitation, violent pressure fluctuations or loss of flow.

Checks and observations: Monitor vapor release, pressure and pump sound. Metallic knocking and large gauge swings are warning signs, not acceptable conditions to maintain.

Around 130°C

Physical condition: Dehydration checkpoint: stable liquid circulation should be restored as water vapor and entrained bubbles are removed.

Procedure: Verify dehydration and stable circulation before proceeding. Reaching 130°C alone does not confirm that the entire system is dry.

Checks and observations: Pressure returns to the normal operating pressure and remains steady. The pump runs smoothly and visible vapor release has subsided. Confirm the system's dehydration acceptance criteria.

130–210°C

Physical condition: Steady heating: after dehydration, liquid circulation and heat transfer become stable.

Procedure: Increase temperature at 10–20°C per hour where approved. Set temporary auxiliary vents to their normal operating positions without isolating required expansion or relief paths.

Checks and observations: Pressure remains stable and the pump runs without abnormal noise.

210–230°C

Physical condition: Secondary gas release: depending on the oil, additional volatile constituents may be released at this stage.

Procedure: Hold for 1–2 hours if required by the fluid condition and approved procedure.

Checks and observations: Watch for renewed vapor release at the expansion tank. Continue heating once conditions are stable.

280°C

Physical condition: Rated operating condition: the oil reaches the intended operating temperature, viscosity is low and the circulation conditions stabilize.

Procedure: Bring the secondary circulation system and heat users into service. Change the heater to automatic temperature control.

Checks and observations: Temperatures and pressures reach the specified operating values. Flow and differential pressure are stable.